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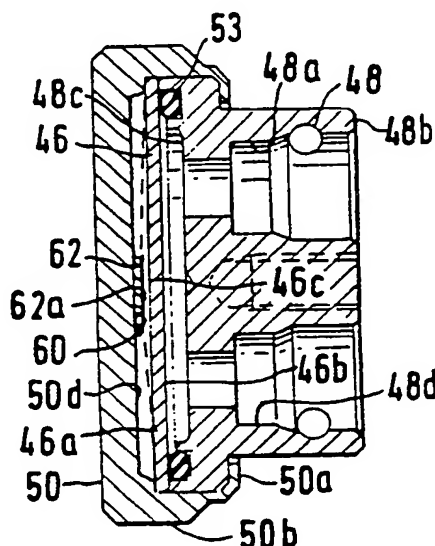
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(54) Damper for hydraulic clutch actuator

(57) A damper (36) for use with a hydraulic clutch actuator system including a master cylinder (10), a slave cylinder (12), and conduit (14) interconnecting the two cylinders. The damper is positioned in the conduit (14) between the two cylinders and includes a diaphragm (46) mounted in a housing (44) and forming a boundary wall of the hydraulic system so that the diaphragm can deflect in response to vibrations transmitted through the hydraulic fluid in the system to effect damping of the vibrations. The housing (44) includes a substantially flat surface (50d) confronting but spaced from the diaphragm. The support surface (50) has a limit means (50e, 62a, 64, 68) interposed between the diaphragm (46) and the support surface (50), to limit the deflection of the centre (46c) of the diaphragm (46) to a predetermined maximum magnitude thereby limiting the stress at the centre of the diaphragm.



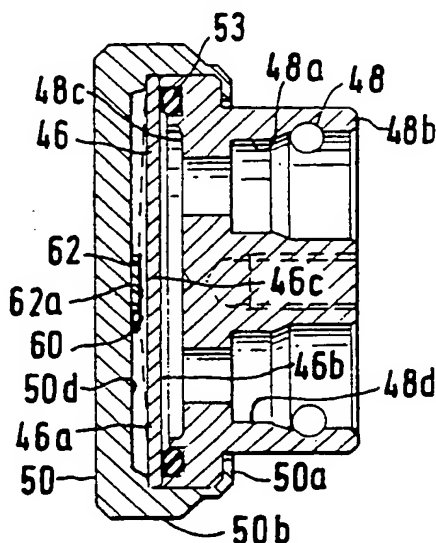




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(21) International Application Number: PCT/GB91/01402 (22) International Filing Date: 19 August 1991 (19.08.91)  (30) Priority data: 604,158 29 October 1990 (29.10.90) US  (71) Applicant: AUTOMOTIVE PRODUCTS PLC [GB/GB]; Patents Section, Tachbrook Road, Leamington Spa, War- wickshire CV31 3ER (GB).  (72) Inventors: LEIGH-MONSTEVENS, Keith, Vernon ; 5622 Larkins Drive, Troy, MI 48098 (US). HARTIG, Julie, Ann ; 450 Beverly Island, Pontiac, MI 48054 (US).  (74) Agent: STANLEY, Michael, Gordon; Patent Department, Automotive Products plc, Tachbrook Road, Leamington Spa, Warks CV31 3ER (GB).		(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (Eu- ropean patent), GB, GB (European patent), GR (Euro- pean patent), IT (European patent), JP, KR, LU (Euro- pean patent), NL (European patent), SE (European pa- tent).  Published With international search report.

(54) Title: DAMPER FOR HYDRAULIC CLUTCH ACTUATOR



## (57) Abstract

A damper (36) for use with a hydraulic clutch actuator system including a master cylinder (10), a slave cylinder (12), and conduit (14) interconnecting the two cylinders. The damper is positioned in the conduit (14) between the two cylinders and includes a diaphragm (46) mounted in a housing (44) and forming a boundary wall of the hydraulic system so that the diaphragm can deflect in response to vibrations transmitted through the hydraulic fluid in the system to effect damping of the vibrations. The housing (44) includes a substantially flat surface (50d) confronting but spaced from the diaphragm. The support surface (50) has a limit means (50e, 62a, 64, 68), interposed between the diaphragm (46) and the support surface (50), to limit the deflection of the centre (46c) of the diaphragm (46) to a predetermined maximum magnitude thereby limiting the stress at the centre of the diaphragm.

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<sup>+</sup> Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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DAMPER FOR HYDRAULIC CLUTCH ACTUATORBackground of the Invention

This invention relates to hydraulic clutch actuators and more particularly to hydraulic clutch actuators employing a damper mechanism.

Hydraulic actuators are known for operating a mechanism at a remote location by way of a master cylinder connected to a slave cylinder installed at the remote location. A conduit interconnects the master cylinder to the slave cylinder and the hydraulic apparatus is filled with hydraulic fluid such that, when the piston of the master cylinder is actuated, the piston of the slave cylinder and consequently the piston rod or output member is simultaneously actuated by displacement of the hydraulic fluid from the master cylinder to the slave cylinder through the conduit.

More particularly, it is known to provide such a hydraulic actuator for operating the clutch of a motor vehicle so that when the clutch pedal of the vehicle is depressed by the driver, the slave cylinder is actuated to operate the clutch in known manner. Preferably, as described in United States Patent 4599860 assigned to the assignee of the present application, the clutch actuator is provided to the motor vehicle manufacturer in an assembled, prefilled form to simplify installation of the actuator on

the vehicle, avoid the inconvenience of potential spillage of hydraulic fluid during on-line filling, eliminate the necessity to bleed or purge the lines of the actuator to facilitate the filling process, and eliminate the need to  
5 test the actuator after installation and filling. Whereas hydraulic clutch actuators, and particularly prefilled clutch actuators, have enjoyed significant commercial success they have the ability to transmit vibrations backwardly through the system from the clutch to the clutch  
10 pedal with the result that the operator may experience unpleasant vibrations at the clutch pedal.

Specifically, imbalances in the crankshaft of the vehicle engine or engine firing impulses are transmitted to the flywheel which undergoes a swashing movement, the  
15 flywheel swashing movement in turn leads to vibrations of the spring fingers of the clutch release mechanism, the vibrations of the spring fingers are transferred to the release bearing of the clutch, and the vibrations propagate backwardly through the hydraulic fluid in the slave  
20 cylinder, through the hydraulic fluid in the conduit interconnecting the slave cylinder and the master cylinder, through the hydraulic fluid in the master cylinder, and thence through the master cylinder push rod to the clutch pedal where they are experienced by the operator as  
25 vibrations of the clutch pedal. The propagated vibrations

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also generate a pedal growl which is audible to the operator as well as a clutch roar which may also be audible to the operator.

Various devices have been proposed in an attempt to attenuate these vibrations. For example, tuned masses have been attached to various parts of the clutch system including the clutch release lever, the slave cylinder push rod, and the clutch pedal. Rubber dampers have also been employed in the master cylinder push rod, rubber hose sections have been employed in the conduit interconnecting the master cylinder and the slave cylinder, and various damper devices have been proposed for installation in the interconnecting conduit. In particular, a damper device as shown in British patent Specification 1362709, and assigned to the assignee of the present invention, may be installed in the conduit interconnecting the master cylinder and the slave cylinder.

Whereas these prior art devices have been successful in varying degrees in attenuating the vibrations in the system, they have each suffered one or more shortcomings. Specifically, the prior art devices have been unduly expensive; or they have actually introduced vibrations into the system by virtue of a hysteresis effect; or they have required a package size that has complicated their installation and placement in the crowded under hood

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environment of a modern day motor vehicle; or they have been difficult to selectively adjust to accommodate varying vehiclular applications; or they have exhibited a relatively short useful product life.

5 Summary of the Invention

The invention is directed to the provision of an improved damper device for use in association with a hydraulic clutch actuator system.

According to the present invention there is provided a  
10 clutch hydraulic vibration damper comprising a housing having a hydraulic fluid chamber therein, a flat plate diaphragm mounted in said housing with its periphery fixed with respect to the housing and having one face constituting a boundary wall of the hydraulic chamber so that the  
15 diaphragm can deflect in response to vibrations transmitted through hydraulic fluid in the chamberto effect damping of the vibrations, and a substantially flat supporting surface on said housing confronting the other face of said diaphragm, the supporting surface being operative to limit  
20 the deflection of the central region of the diaphragm to a predetermined maximum magnitude to limit the stress at the center of the diaphragm to an acceptable level.



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This arrangement allows the diaphragm to operate effectively to attenuate vibrations in the system and yet the stresses placed on the central regions of the diaphragm are limited in such a manner as to significantly prolong the useful life of the diaphragm and thereby of the damper.

Preferably said supporting surface has a limit means interposed between the supporting surface and the other diaphragm face. This arrangement provides a simple and effective means of incorporating the limit means into the damper design.

Conveniently the limit means comprises a stop member defined on the supporting surface and extending from said surface toward the central region of the diaphragm to selectively limit the maximum magnitude of deflection of the central region of the diaphragm.

Alternatively the limit means comprises a spring member positioned between the supporting surface and the other diaphragm face to limit the excursions of the central region of the diaphragm in accordance with the parameters of the spring.

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In another embodiment of the invention, the limit means comprises a liquid substance positioned between the supporting surface and the other diaphragm face. The excursions of the central region of the diaphragm may be  
5 limited in accordance with the parameters of the liquid and in accordance with the extent to which the liquid fills the space between the other diaphragm face and the housing surface.

The invention also provides a method of damping  
10 vibrations occurring in the hydraulic fluid in a clutch hydraulic actuator system, said method providing a diaphragm having a face forming a boundary wall of the system so that the diaphragm can deflect in response to vibrations transmitted through the hydraulic fluid in the system to  
15 effect damping of the vibrations, and defines a flat supporting surface confronting but spaced from the other face of the diaphragm or aperture to limit the deflection of the central region of the diaphragm to a predetermined maximum.

20 The space between the supporting surface and the other diaphragm face may be selectively varied to selectively accommodate hydraulic control systems of varying characteristics.

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In the disclosed embodiment of the invention, the diaphragm is fixed at its periphery to a housing and the housing defines the supporting surface and the varying step of the invention methodology comprises selectively inserting one or more shim members, of various thicknesses in the space between the supporting surface and the other diaphragm face. This methodology provides a simple and effective means of altering the response of the damper to suit varying system characteristics.

10 Brief Description of the Drawings

FIGURE 1 is a somewhat schematic view of a hydraulic clutch actuator employing the invention damper;

FIGURE 2 is a cross sectional view taken on line 2-2 of FIGURE 1;

15 FIGURE 3 is a cross sectional view taken on line 3-3 of FIGURE 2;

FIGURE 4 is a fragmentary perspective view of the damper of FIGURES 1-3;

FIGURE 5, 6, 7 and 8 are views of modifications of the damper of FIGURES 1-4; and

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FIGURES 9, 10, 11 and 12 are force versus deflection curves for the FIGURES 1-4 embodiment, the FIGURE 5 embodiment, the FIGURE 6 embodiment, and the FIGURE 7 embodiment, respectively.

5     Detailed Description of the Preferred Embodiments

10     The hydraulic clutch actuator shown schematically in Figure 1 includes a master cylinder 10, a slave cylinder 12, and a conduit 14 extending between the outlet or discharge of the master cylinder and the inlet of the slave cylinder.

15     Master cylinder 10 includes an input rod 16 connected in known manner to the clutch pedal 18 of an associated motor vehicle so that pivotal movement of the clutch pedal by the vehicle operator moves a piston of the master cylinder in known manner to discharge pressure fluid from the cylinder. Cylinder 10 further includes a flange 10a to facilitate attachment of the master cylinder to the firewall 20 of the vehicle.

20     Slave cylinder 12 is secured as by a bracket 22 to the bell housing 23 enclosing the clutch 24 of the vehicle and includes an output rod 25 coacting in known manner with a clutch release lever 26 so that pivotal movement of clutch pedal 18 by the operator results in discharge of pressure fluid from master cylinder 10 for conveyance through conduit 25 14 to slave cylinder 12 to provide extension of output rod 25 and pivotal movement of release lever 26 to move the clutch release bearing 27 in a direction to disengage the clutch 24. Clutch 24 is driven in known manner by a flywheel 30 which in turn is driven by an engine crankshaft

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32. The invention damper 36 is interposed in conduit 14 and is connected to the outlet of master cylinder 10 by a conduit portion 14a and to the inlet of slave cylinder 12 by a conduit portion 14b.

5           Damper assembly 36 includes a damper 38 and a bracket 40 to facilitate attachment of damper 36 to a fixed vehicle panel 42.

          Damper 38 includes a housing assembly 44 and a diaphragm 46.

10           Housing assembly 44 has a generally cylindrical configuration and includes a main body housing member 48 and a cover member 50.

          Main body housing member 48 is formed of a suitable metallic material and includes an inlet port 48a extending from the front face 48b to the rear face 48c of the housing member; an outlet port 48d extending from the front face 48b to the rear face 48c of the housing member; a pair of threaded bores 48e opening in the front face of the housing member for receipt of bolts 52 passing through the main body portion 40a of bracket 40 and an annular circumferential groove 48f in the rear face of the main body housing member for receipt of an O-ring 53.

20           Cover 50 is of generally cylindrical configuration, is formed of a metallic material, and includes a lip portion 50a crimped over an enlarged portion

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48g of main body member 48; an annular side wall portion 50b circumferentially surrounding the side wall 48h of main body enlarged portion 48g and a main body cover portion 50c spanning the rear face 48c of the main body member 48 in parallel spaced relation thereto to define a sealed chamber 54 between the main body member rear face 48c and the front face 50d of cover portion 50c.

Diaphragm 46 is formed of a rigid metallic material having a high natural frequency so that it can follow the frequency of the relevant vibration in the actuator system and having preferably a low loss hysteresis. Preferably the diaphragm comprises a sheet steel plate. Diaphragm 46 is clamped around its periphery between cover 50 and main body housing member 48 and, specifically, is clamped between an annular surface 50e proximate the junction between the cover side wall portion 50b and cover portion 50c and a corresponding annular surface 48i defined by the extreme outer periphery of main body member 48 in surrounding relation to groove 48f.

As seen in Figure 3, the various elements are sized such that, in assembled relation, the O-ring 53 is flattened between disk 46 and the front surface of groove 48f to provide an effective seal as between the housing main body member and the diaphragm.

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Diaphragm 46 will be seen to extend across chamber 54 to divide chamber 54 into a front chamber 54a and a rear chamber 54b with rear chamber 54b defined between the rear face 46a of the diaphragm and the front face 50d of cover main body portion 50c and with the front chamber 54a defined between the front face 46b of the diaphragm and the rear face 48c of main body housing member 48.

It will be seen that when the free end of conduit portion 14a is inserted into inlet port 48a and the free end of conduit portion 14b is inserted into discharge 48d, chamber 54a is in communication with the inlet and outlet ports so that the front face 46b of diaphragm 46 constitutes a barrier wall of the hydraulic system so that the diaphragm can deflect in response to vibrations transmitted through hydraulic fluid in the system to effect damping of the vibrations.

As the diaphragm deflects in response to the vibrations transmitted through hydraulic fluid in the system, the center region 46c of the diaphragm inherently undergoes the maximum deflection and thereby experiences the maximum stress so that, if the deflection of the center region of the diaphragm is not controlled, cracking of the center region of the diaphragm becomes a failure mode that may severely limit the fatigue life of a diaphragm.

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According to the invention, means are provided to selectively limit the deflection of the center region of the diaphragm whereby to increase the fatigue life of the diaphragm by moving the operating stress on the stress over frequency curve to an acceptable level and shifting the area of stress away from the center of the diaphragm.

This deflection limiting is accomplished in the Figures 1-4 embodiment by providing an upset or raised portion 50e at the center of the inner surface 50d of the cover 50 to define a stop surface 50f in spaced confronting relation to the rear face 46a of the central region 46c of the diaphragm so as to selectively limit the maximum extent of deflection or excursion allowed by the central region of the diaphragm during its damping activity. For example, for a diaphragm having a diameter of 1.750 inches, the upset portion 50e of the cover member may be sized and configured to provide a space 60 between the front face 50f of the upset portion and the rear face of the diaphragm of 0.030 inches.

As previously indicated, the provision of a limit stop in spaced confronting relation to the rear face of the center portion of the diaphragm has the effect of limiting the deflection of the center portion of the diaphragm during use and the consequent effect of significantly lengthening the fatigue life of the diaphragm by moving the operating



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stress on the stress over frequency curve to an acceptable level and shifting the area of stress away from the center of the diaphragm. For example, prior art damper units of the type shown in British patent 1562709, operating under an actuator system pressure of 725 psi, have failed at less than 100,000 cycles whereas the damper of the invention, with the provision of the stop limit means in confronting relation to the rear face of the central region of the diaphragm, has endured over 1,000,000 cycles without failure.

In addition to significantly increasing the fatigue life of the diaphragm, the invention limit stop arrangement provides the further advantage that the distance between the face of the limit stop and the rear face of the central region of the diaphragm may be selectively varied simply by varying the height of the upset portion to thereby allow the invention damper to selectively accommodate hydraulic control systems of varying characteristics.

The behavior of the diaphragm of the invention damper is seen in the force versus deflection graph of Figure 9 wherein the hysteresis portion of the curve represents the behavior of the central region of the diaphragm prior to encountering the stop face and the straight line verified portion of the curve illustrates the

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fact that the deflection of the central region of the diaphragm does not increase beyond the force required to bottom the diaphragm against the face 50f.

5           The damper embodiment seen in Figure 5 is identical to the embodiment of Figures 1-4 with the exception that the upset portion 50e of the main body portion of the cover 50 is eliminated and replaced by a separate button member 62 which may be formed of a suitable elastomeric material such, for example, as a polymeric material. The button 62 is suitably secured to the front 10 face 50d of the main body portion of the cover member and, as with the Figures 1-4 embodiment, defines a front face 62a in confronting spaced relation to the rear face 46a of the central region of the diaphragm which acts to limit the deflection of the center region of the diaphragm and thereby 15 significantly increases the fatigue life of the diaphragm. As with the upset portion 50e of the Figures 1-4 embodiment, the thickness of the button 62 may be selectively varied to vary the size of the space 60 between the front face 62a and 20 the rear face of the diaphragm to accommodate hydraulic control systems of varying hydraulic characteristics. The force versus deflection behavior of the embodiment of Figure 5 is shown in Figure 10.

25           The embodiment of Figure 6 is generally similar to the embodiment of Figures 1-4 with the exception that the

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upset portion 50e of the main body portion of the cover member is eliminated, a circular recess 50g is provided in the front face of the main body cover portion 50c, and a Belleville spring washer 64 is positioned in the rear chamber 54b between the rear face 46a of the diaphragm and the front face 50d of the cover main body portion with the outer circular edge of the washer positioned in recess 50g so that the Belleville spring washer acts to selectively resist and limit the rearward deflection of the diaphragm in a manner similar to the operation of the upset portion 50e of the Figures 1-4 embodiment and the elastomeric button 62 of the Figure 5 embodiment. The force versus deflection behavior of the embodiment of Figure 6 is illustrated in the graph of Figure 11.

The Figure 7 embodiment is generally similar to the embodiment of Figures 1-4 with the exception that the unit includes an O-ring seal 66 positioned in an annular groove 48j in the main body housing member, the upset portion 50e is eliminated, and a suitable liquid 68 is positioned in the chamber 54b. Liquid 68, which may comprise, for example, silicone oil of various viscosities, preferably partially fills chamber 54 to leave an air gap 70 at the upper end of the chamber, and acts to limit the deflection of the diaphragm 46. The force versus deflection

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behavior of the embodiment of Figure 7 is seen graphically in Figure 12.

The invention embodiment seen in Figure 8 is generally similar to the embodiment of Figure 5 except that the elastomeric button 62 is replaced with a disk-like shim member 68 which has a size corresponding to the size of chamber 54b so that the front face 68a of the shim member provides a limit stop with respect to the entire rear surface area 46a of the diaphragm. As a practical matter, however, due to the fact that the periphery of the diaphragm is fixed to the housing, the shim 68 acts to only limit the rearward deflection of the central region of the diaphragm. The construction of Figure 8 has the advantage that the shims may be firmly positioned in the pocket or depression defined in the inner face of the main body portion of the cover within surface 48f and has the further advantage that the thickness of the shims may be readily varied to accommodate hydraulic control systems of varying hydraulic characteristics and/or a plurality of relatively thin shims may be utilized to position the front face 68a of the shim or shim stack in desired spaced relation with respect to the rear face of the diaphragm and thereby provide the precise deflection behavior required to accommodate a particular hydraulic control system.

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The clutch actuator is preferably provided to the motor vehicle manufacturer in a prefilled form with hydraulic fluid filling the liquid volumes of the master cylinder, slave cylinder, conduit and damper.

5           The invention damper assemblies will be seen to provide a means of significantly increasing the fatigue life of the damper without decreasing the effectiveness of the damper and will be further seen to provide a convenient means of selectively varying the deflection characteristics  
10       of the damper mechanism to accommodate hydraulic control systems of varying hydraulic characteristics.

         Whereas preferred embodiments of the invention have been illustrated and described in detail it will be apparent that various changes may be made in the disclosed  
15       embodiments without departing from the scope or spirit of the invention.

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CLAIMS

1. A clutch hydraulic vibration damper comprising a housing having a hydraulic fluid chamber therein, a flat plate diaphragm mounted in said housing with its periphery fixed with respect to the housing and having one face constituting a boundary wall of the hydraulic chamber so that the diaphragm can deflect in response to vibrations transmitted through hydraulic fluid in the chamber to effect damping of the vibrations, and a substantially flat surface on said housing confronting the other face of said diaphragm, the supporting surface being operative to limit the deflection of the central region of the diaphragm to a predetermined maximum magnitude to limit the stress at the center of the diaphragm to an acceptable level.
2. A vibration damper according to Claim 1 wherein said support surface has a limit means interposed between said support surface and said other diaphragm face.
3. A vibration damper according to Claim 1 or Claim 2 wherein said limit means comprises a stop member defined on said supporting surface and extending from said surface toward said central region of said diaphragm.

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4. A vibration damper as claimed in Claim 3 wherein the stop member is a raised central portion in the support surface.
5. A vibration damper as claimed in Claim 4 wherein the raised central portion comprises an elastomeric button member.
6. A vibration damper according to Claim 1 or Claim 2 wherein a limit means is interposed between said surface and the diaphragm and said limit means comprises a spring member.
7. A vibration damper according to Claim 1 or Claim 2 wherein a limit means is interposed between said surface and the diaphragm and said limit means comprises a liquid substance positioned between said supporting surface and said other diaphragm face.
8. A vibration damper as claimed in any one of Claims 1 to 7 wherein the housing further includes inlet and outlet ports for connection into a hydraulic clutch system comprising a master cylinder, a slave cylinder and conduit therebetween, and the chamber is in communication with said ports, and the diaphragm extends across said chamber with one face thereof

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communicating with said ports so as to form a boundary wall of said system so that the diaphragm deflects in response to vibrations transmitted through hydraulic fluid in the system to effect damping of the vibrations.

5

9. A vibration damper as claimed in any one of Claims 1 to 6 wherein the housing comprises a housing body and a cap and the supporting surface is located on the cap which is clamped to the housing body to sandwich the outer periphery of the diaphragm therebetween.

10

10. A clutch actuator system comprising a master cylinder, a slave cylinder, a damper according to any one of Claims 1 to 9, and conduit interconnecting the cylinders and damper, wherein said actuator system is provided to the motor vehicle manufacturer in prefilled form with hydraulic fluid filling the liquid volumes in said master cylinder, said slave cylinder, and said damper.

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11. A method of damping vibrations occurring in the hydraulic fluid in a hydraulic clutch actuator system, said method comprising: providing a diaphragm having a face forming a boundary wall of the system so that the

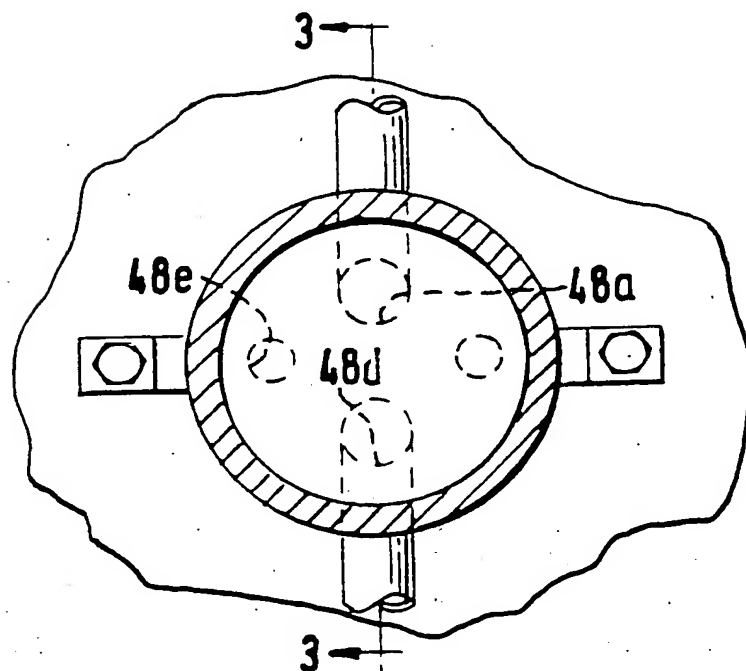
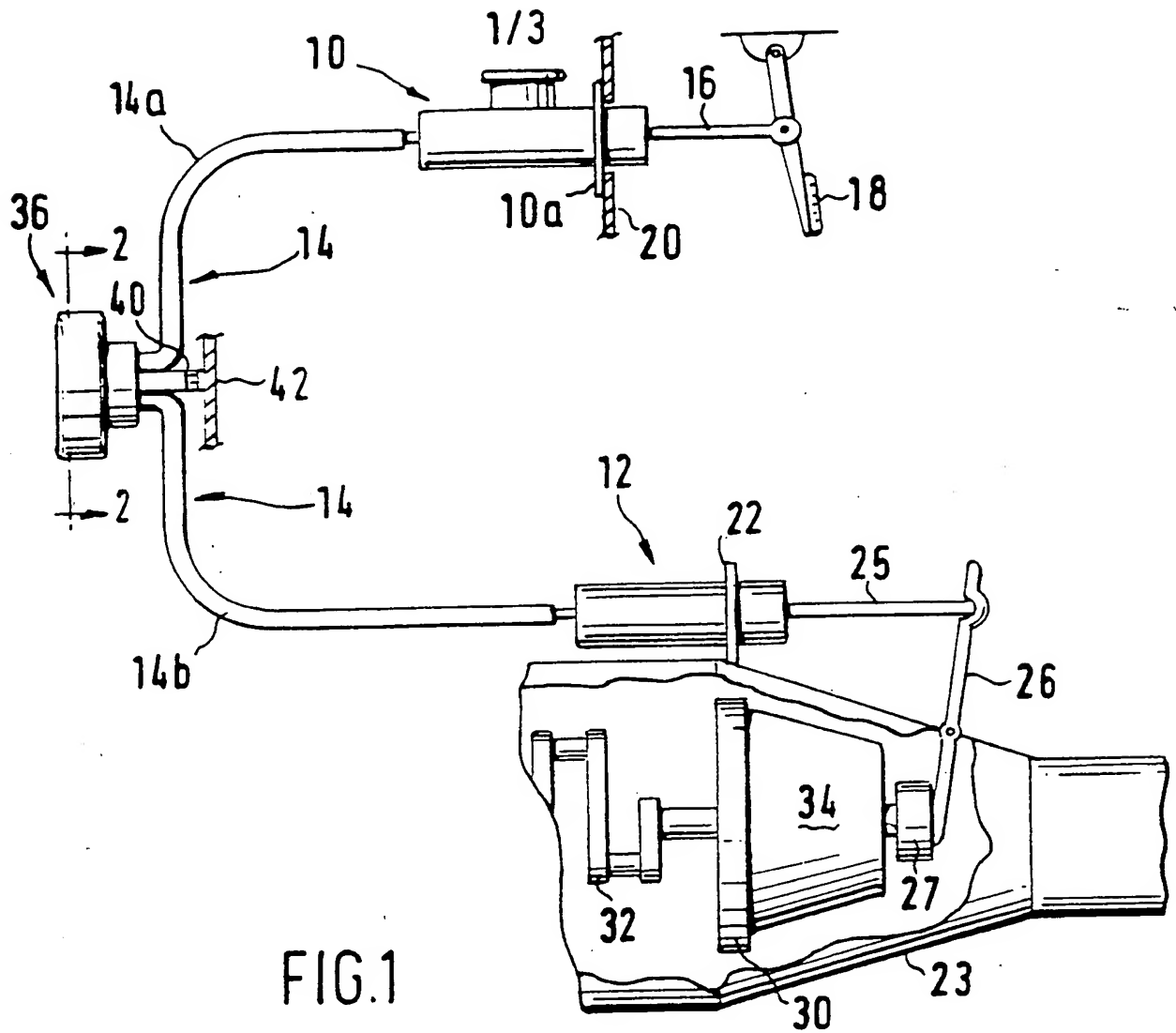
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diaphragm can deflect in response to vibrations transmitted through the hydraulic fluid in the system to effect damping of the vibrations; and defining a flat supporting surface confronting but spaced from the other face of the diaphragm and operative to limit the deflection of the central region of the diaphragm to a predetermined maximum magnitude.

12. A method as claimed in Claim 11, wherein the space between said stop surface and said other diaphragm face is varied selectively to selectively accommodate hydraulic control systems of varying characteristics.
13. A method according to Claim 12 wherein the diaphragm is fixed at its periphery to a housing and the housing defines the supporting surface wherein: said varying step comprises selectively inserting one or more shim members of various thicknesses in the space between said housing surface and said other diaphragm face.



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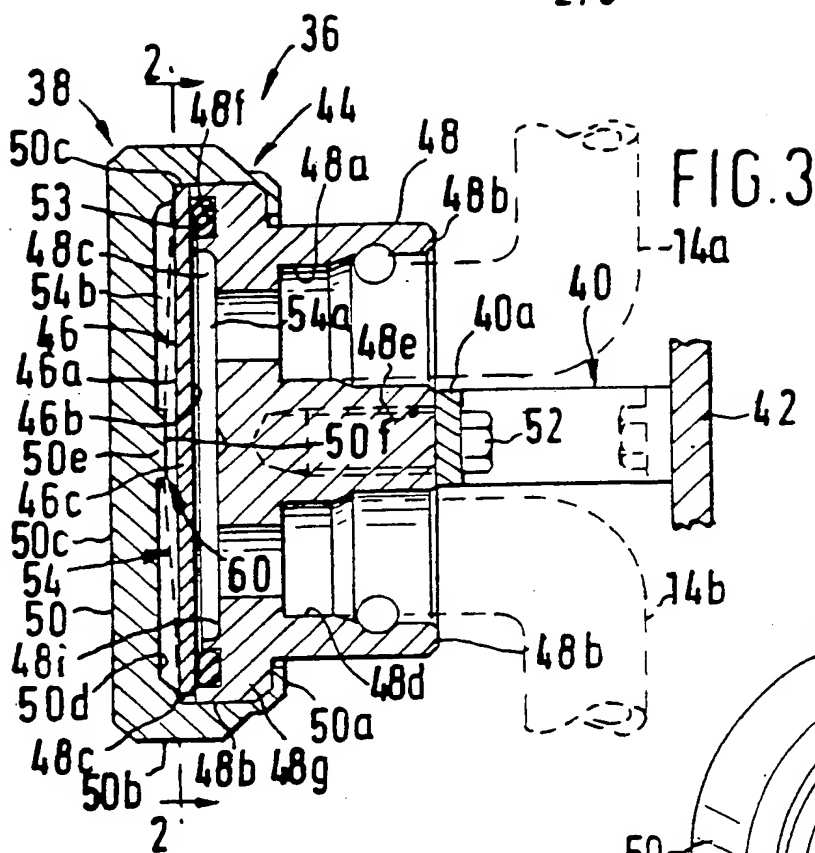


FIG. 3

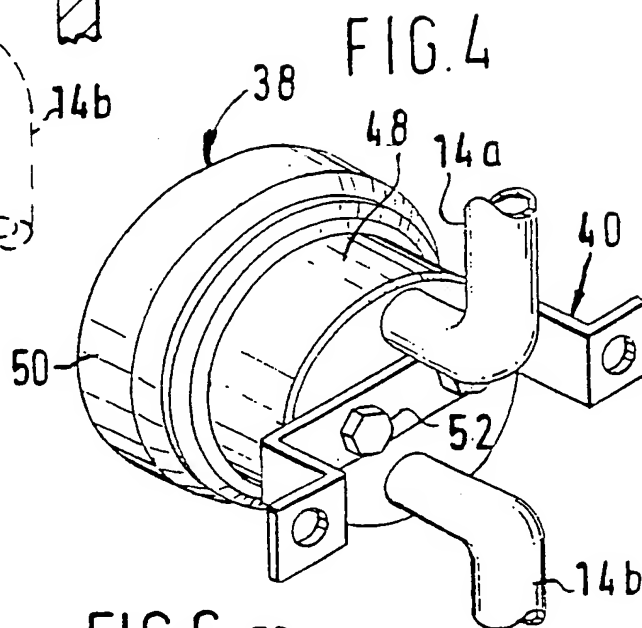


FIG. 4

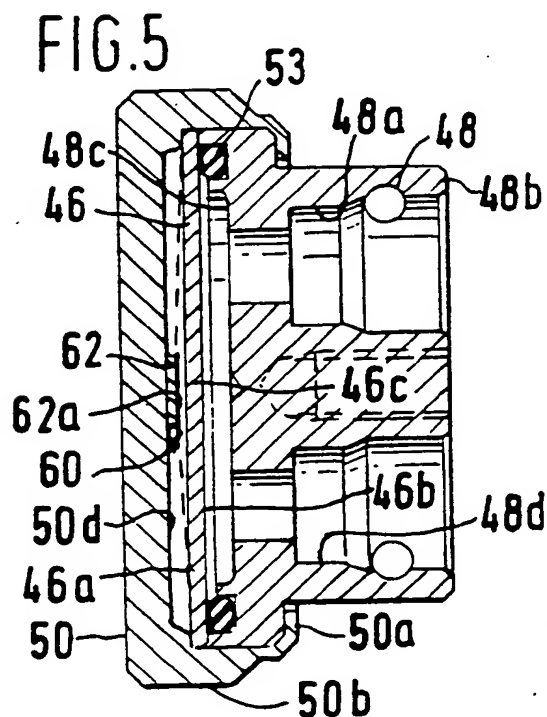


FIG. 5

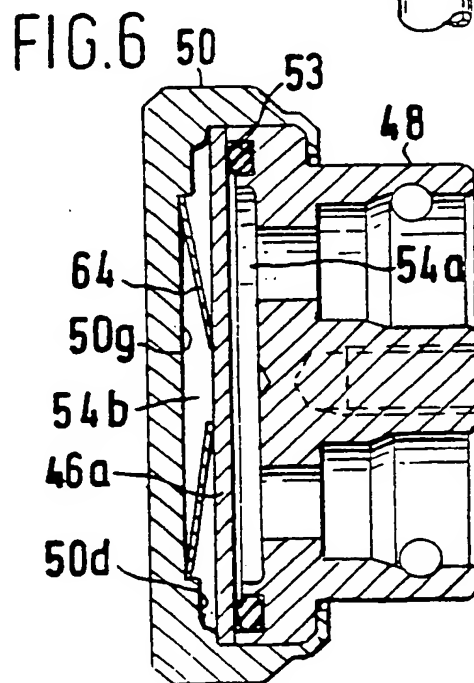
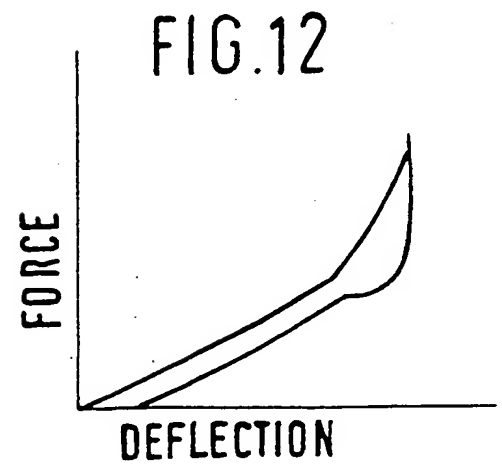
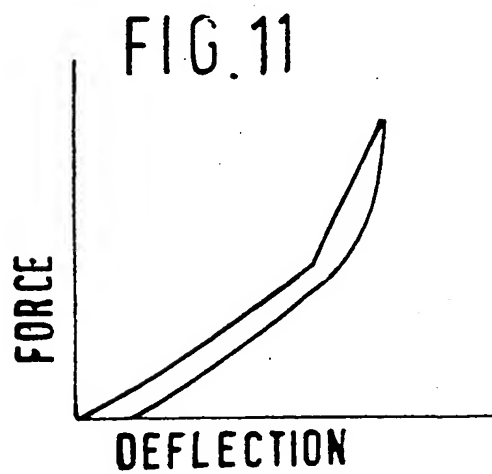
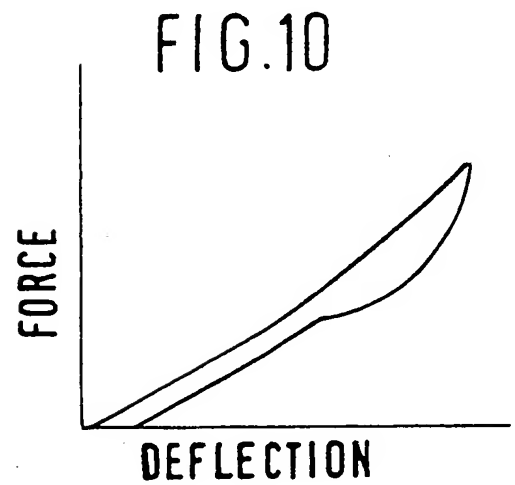
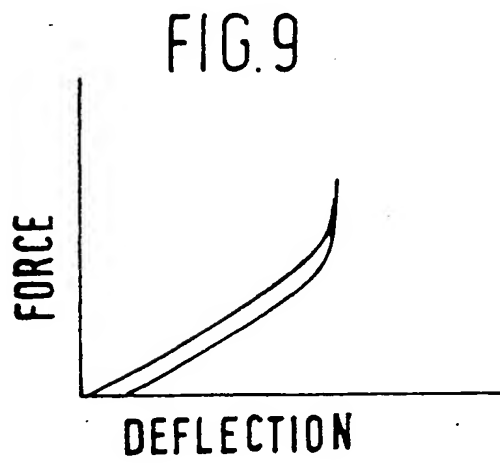
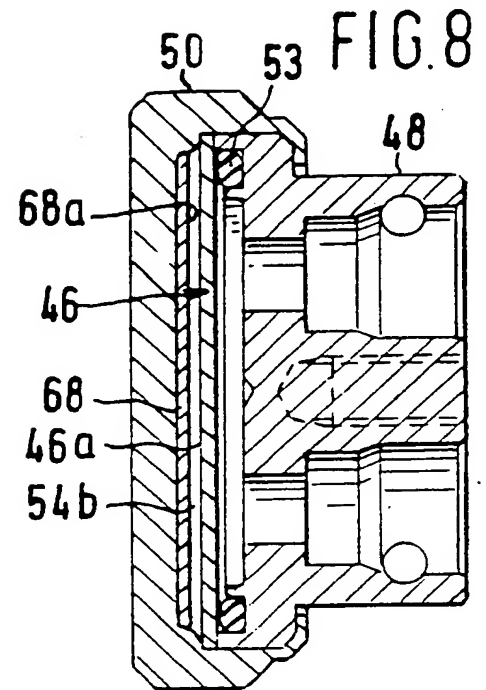
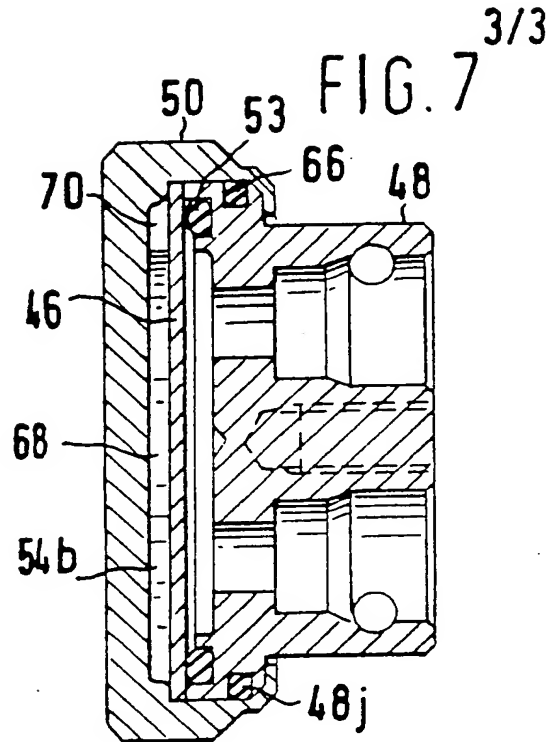


FIG. 6

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## International Application No.

International Application No.

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	GB,A,1 089 667 (RENAULT) 1 November 1967 see the whole document ---	1,2,5,6, 8-13
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. GB 9101402  
SA 50653**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on  
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